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(54) Method of making a camshaft

Verfahren zur Herstellung einer Nockenwelle

Méthode de fabrication d'un arbre à cames

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Description

This invention relates to a method of making a camshaft for reciprocating piston engines where the cams and shaft are produced as individual elements and are fastened together forming the camshaft.

One method of manufacturing camshafts involves forming the cams separately by methods such as powdered metallurgy. The cams are then fastened to a hollow tube using known fastening processes, such as welding, brazing or expansion of the hollow tube. Bearing or journal surfaces are machined onto the hollow tube between cams. Another method of attaching the cams, described in US-A-4 858 295, leaves a plurality of projections on the outside of the hollow tube between cams. According to this method, an expander tool having circumferentially spaced protrusions is inserted into the tube, thereby expanding portions of the wall of the tube into spaced apart axially extending grooves provided on the cylindrical inside surface of the cams to be attached. These projections must be removed in order to form the journal surfaces.

The displacement of material caused by an expander tool during expansion of the hollow tube induces work hardening and stress into the tube. Limiting work hardening reduces the risk of failure due to tube splitting.

According to the present invention, there is provided a method of forming a camshaft tube comprising the steps of providing a hollow tube, providing an axially extending retractable mandrel, the retractable mandrel having a first portion and a second portion adjacent the first portion, the diameter of the first portion being larger than the diameter of the second portion, the second portion being an end of the retractable mandrel, inserting the retractable mandrel into the hollow tube, positioning the retractable mandrel whereby the first portion of the retractable mandrel is positioned under a first section of the hollow tube; providing a swaging tool and mechanically reducing the first section of the hollow tube by pushing the hollow tube through the swaging tool, the retractable mandrel also being moved to keep the first portion of the retractable mandrel positioned under the section of the hollow tube being reduced, retracting the retractable mandrel to position the second portion of the retractable mandrel under a second section of the hollow tube, mechanically reducing the second section of the hollow tube, repeating the steps of positioning the retractable mandrel whereby the first portion of the retractable mandrel is positioned under a further first section of the hollow tube, mechanically reducing the first section of the hollow tube by pushing the hollow tube through the swaging tool, the retractable mandrel also being moved to keep the first portion of the retractable mandrel positioned under the section of the hollow tube being reduced, retracting the retractable mandrel to position the second portion of the retractable mandrel under a further second section of the hollow tube, mechanically reducing the second section of the hollow tube by pushing the hollow tube through the swaging tool, thereby forming a plurality of first sections and second sections, the inner diameter of a first section being larger than the inner diameter of a second section, said first and second sections defining thinner wall zones and thicker wall zones respectively, providing a plurality of cam elements, each cam element including an axial opening, inserting the hollow tube into the cam elements, each cam element being positioned about a reduced diameter zone, and expanding the reduced inner diameter zones of the hollow tube into mechanical interference engagement with the cam elements; wherein the areas of the hollow tube adjacent the reduced inner diameter zones define larger inner diameter zones and the larger inner diameter zones do not expand during the step of expanding the reduced diameter zones; and whereby said expanding step is carried out by using an expander tool having a diameter larger than the inner diameter of the thicker wall zones and smaller than the inner diameter of the thinner wall zones to expand the thicker wall zones of the hollow tube into mechanical interference engagement with the cam elements by inserting the expander tool into the hollow tube.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:-

Figure 1 is a cross-section in part of a camshaft;

Figure 2 is a cross-section of a hollow tube shown in Figure 1 after it has been mechanically reduced, showing cams located about the tube;

Figure 3 is a cross-section view taken along line 3-3 of Figure 2;

Figure 4 is a cross-section of the camshaft showing the cams after an expander tool has moved partially through the hollow tube; and

Figures 5A to 5D are cross-sections of a hollow tube illustrating the steps of forming the hollow tube shown in Figure 2 using a retractable mandrel.

Referring to the drawings and more particularly to Figure 1, the manufacture of the camshaft is accomplished by slipping cams 10 over a hollow tube 13. Other elements in addition to cams 10 may be attached to the hollow tube 13 using this method. This includes timing gears, thrust washers, bearing rings, etc. The hollow tube 13 has a plurality of areas 16 which have a thicker wall thickness than the adjacent areas 18. The cams 10 are positioned about the thicker wall areas 16. Some of the thinner wall areas 18 are used as bearing or journal surfaces.

The hollow tube 13 is preferably made of formable steel having a maximum hardness of R_c30. The cams 10 are preferably made of steel which is hardenable to a minimum hardness of R_c55. Powder forged AISI 4680 series material has also been successfully used as cams 10.

The method for forming the hollow tube 13 with a plurality of thinner areas (or first sections) 18 and thicker areas (or second sections) 16 utilises a swaging operation as illustrated in Figures 5A through 5D. A retractable mandrel 50 is inserted into a hollow tube 13. The retractable mandrel 50 has a first portion 54 and an adjacent second portion 52. The diameter of the first portion 54 is larger than the diameter of the second portion 52. As shown in the drawings, the second portion 52 is an end portion on a free end of the retractable mandrel 50. The other end of the retractable mandrel 50 is attached to a machine (not shown).

The retractable mandrel 50 is positioned within the hollow tube 13 with the larger diameter first portion 54 under a swaging tool or die 60, as shown in Figure 5A. The hollow tube 13 and retractable mandrel 50 are then pushed through the swaging tool 60, from left to right in Figures 5A to 5D, reducing the outer diameter of the hollow tube 13 and forming a thinner area or first section 18 of the hollow tube 13. The retractable mandrel 50 is then retracted to the left to position the smaller diameter second portion 52 under swaging tool 60. The hollow tube is continued to be pushed through the swaging tool 60, reducing the outer diameter of the hollow tube 13 and forming a thicker area or second section 16 of the hollow tube 13, as shown in Figure 5B. After the second section 16 is formed, the retractable mandrel 50 and the hollow tube 13 are both pushed through the swaging tool 60, as shown in Figure 5C, forming another thinner area or first section 18. The retractable mandrel 50 is then retracted to the left to position the smaller diameter second portion 52 under the swaging tool 60 and the hollow tube 13 is continued to be pushed through the swaging tool 60, forming an additional thicker area or second section 16 of the hollow tube 13, as shown in Figure 5D.

The steps of forming additional first sections 18 and second sections 16 are repeated until a complete tube 13 with multiple thinner areas 18 and multiple thicker areas 16, as shown in Figure 2, is formed. Preferably, the swaging tool 60 reduces the outer diameter of the hollow tube 13 to the final diameter, such that no additional machining or reduction of the hollow tube 13 is required.

The diameter of the first and second portions 54, 52 of the retractable mandrel 50 determine the inner diameter of the first and second sections 18, 16 of the hollow tube 13. Since the outer diameter of the hollow tube 13 is kept constant, the first sections 18 of the hollow tube 13 are thinner than the second sections 16 of the hollow tube 13.

The preferred axial length for the thicker areas 16 is slightly less than the axial length of a cam 10. This should minimise or preclude any change in the outer diameter of the thinner areas 18 when the cams 10 are fastened to the hollow tube 13.

The cams 10 are then assembled on the hollow tube 13 as shown in Figure 2. Each cam 10 is aligned with a thicker wall area 16. The axial opening of the cam 10 is slightly larger than the outer diameter of the hollow tube, creating a slight gap between the cam 10 and the tube 13 as shown in Figures 2 and 3.

The cams 10 are held in the proper angular alignment while an expander tool 36 is inserted into the hollow tube 13. Figure 4 shows the expander tool 36 after it has been inserted past two cams 10. The outer diameter of the expander tool 36 is larger than the inner diameter of the thicker wall areas 16. The outer diameter is also smaller than the inner diameter of the thinner wall areas 18. As the expander tool 36 is inserted into the hollow tube 13, the thicker wall areas 16 are expanded outward into contact with the axial opening of the cam 10. This expansion locks the cams 10 and the hollow tube 13 into mechanical interference engagement, thereby providing axial retention of the cams 10. Since the outer diameter of the expander tool 36 is smaller than the inner diameter of the thinner wall areas 18, these areas are not expanded during the insertion of the expander tool 36. Therefore, these areas 18 typically do not require any additional post assembly machining.

Claims

1. A method of forming a camshaft tube comprising the steps of providing a hollow tube (13), providing an axially extending retractable mandrel (50), the retractable mandrel (50) having a first portion (54) and a second portion (52) adjacent the first portion (54), the diameter of the first portion (54) being larger than the diameter of the second portion (52), the second portion (52) being an end of the retractable mandrel (50), inserting the retractable mandrel (50) into the hollow tube (13), positioning the retractable mandrel (50) whereby the first portion (54) of the retractable mandrel (50) is positioned under a first section (18) of the hollow tube (13); providing a swaging tool (60) and mechanically reducing the first section (18) of the hollow tube (13) by pushing the hollow tube (13) through the swaging tool (60), the retractable mandrel (50) also being moved to keep the first portion (54) of the retractable mandrel (50) positioned under the section of the hollow tube (13) being reduced, retracting the retractable mandrel (50) to position the second portion (52) of the retractable mandrel (50) under a second section (16) of the hollow tube (13), mechanically reducing the second section (16) of the hollow tube (13), repeating the steps of positioning the retractable mandrel (50) whereby the

first portion (54) of the retractable mandrel (50) is positioned under a further first section (18) of the hollow tube (13), mechanically reducing the first section (18) of the hollow tube (13) by pushing the hollow tube (13) through the swaging tool (60), the retractable mandrel (50) also being moved to keep the first portion (54) of the retractable mandrel (50) positioned under the section of the hollow tube being reduced, retracting the retractable mandrel (50) to position the second portion (52) of the retractable mandrel (50) under a further second section (16) of the hollow tube (13, mechanically reducing the second section (16) of the hollow tube (13) by pushing the hollow tube (13) through the swaging tool (60), thereby forming a plurality of first sections (18) and second sections (16), the inner diameter of a first section being larger than the inner diameter of a second section, said first and second sections defining thinner wall zones and thicker wall zones respectively, providing a plurality of cam elements (10), each cam element (10) including an axial opening, inserting the hollow tube (13) into the cam elements (10), each cam element (10) being positioned about a reduced inner diameter zone, and expanding the reduced inner diameter zones of the hollow tube (13) into mechanical interference engagement with the cam elements (10); wherein the areas of the hollow tube (13) adjacent the reduced inner diameter zones define larger inner diameter zones and the larger inner diameter zones do not expand during the step of expanding the reduced diameter zones; and whereby said expanding step is carried out by using an expander tool (36) having a diameter larger than the inner diameter of the thicker wall zones and smaller than the inner diameter of the thinner wall zones to expand the thicker wall zones of the hollow tube (13) into mechanical interference engagement with the cam elements (10) by inserting the expander tool (36) into the hollow tube (13).

Patentansprüche

1. Verfahren zum Herstellen eines Rohres für eine Nockenwelle, mit den Schritten: Bereitstellen eines hohlen Rohres (13), Bereitstellen eines sich axial erstreckenden, zurückziehbaren Dorns (50), wobei der zurückziehbare Dorn (50) einen ersten Abschnitt (54) und einen zweiten Abschnitt (52) benachbart zu dem ersten Abschnitt (54) hat, wobei der Durchmesser des ersten Abschnitts (54) größer ist als der Durchmesser des zweiten Abschnitts (52), wobei der zweite Abschnitt (52) ein Ende des zurückziehbaren Dorns (50) ist, Einsetzen des zurückziehbaren Dorns (50) in das hohle Rohr (13), Positionieren des zurückziehbaren Dorns (50), wodurch der erste Abschnitt (54) des zurückziehbaren Dorns (50) unter einem ersten Teil (18) des hohlen Rohrs (13) angeordnet wird; Bereitstellen eines Schmiedewerkzeugs (60) und mechanisches Reduzieren des ersten Teils (18) des hohlen Rohrs (13) durch Schieben des hohlen Rohrs (13) durch das Schmiedewerkzeug (60), wobei der zurückziehbare Dorn (50) auch bewegt wird, um den ersten Abschnitt (54) des zurückziehbaren Dorns (50) unter dem Teil des hohlen Rohrs (13) angeordnet zu halten, der reduziert wird, Zurückziehen des zurückziehbaren Dorns (50), um den zweiten Abschnitt (52) des zurückziehbaren Dorns (50) unter einem zweiten Teil (16) des hohlen Rohrs (13) anzuordnen, mechanisches Reduzieren des zweiten Teils (16) des hohlen Rohrs (13), Wiederholen der Schritte des Anordnens des zurückziehbaren Dorns (50), wodurch der erste Abschnitt (54) des zurückziehbaren Dorns (50) unter einem weiteren ersten Teil (18) des hohlen Rohrs (13) angeordnet wird, mechanisches Reduzieren des ersten Teils (18) des hohlen Rohrs (13) durch Schieben des hohen Rohrs (13) durch das Schmiedewerkzeug (60), wobei der zurückziehbare Dorn (50) auch bewegt wird, um den ersten Abschnitt (54) des zurückziehbaren Dorns (50) unter dem Teil des hohlen Rohrs zu halten, der reduziert wird, Zurückziehen des zurückziehbaren Dorns (50), um den zweiten Abschnitt (52) des zurückziehbaren Dorns (50) unter einem weiteren zweiten Teil (16) des hohlen Rohrs (13) anzuordnen, mechanisches Reduzieren des zweiten Teils (16) des hohlen Rohrs (13) durch Schieben des hohlen Rohrs (13) durch das Schmiedewerkzeug (60), wodurch eine Vielzahl von ersten Teilen (18) und zweiten Teilen (16) gebildet wird, wobei der innere Durchmesser eines ersten Teils größer ist als der innere Durchmesser eines zweiten Teils, wobei die ersten und zweiten Teile dünnere Wandbereiche und dickere Wandbereiche bilden, Bereitstellen einer Vielzahl von Nockenelementen (10), wobei jedes Nockenelement (10) eine axiale Öffnung aufweist. Einsetzen des hohlen Rohrs (13) in die Nockenelemente (10), wobei jedes Nockenelement (10) um einen Bereich mit reduziertem innerem Durchmesser herum angeordnet wird, und Aufweiten der Bereiche mit reduziertem innerem Durchmesser des hohlen Rohrs (13) in mechanischen Festsitzeingriff mit den Nockenelementen (10); wobei die Bereiche des hohlen Rohrs (13) benachbart zu den Bereichen mit reduziertem innerem Durchmesser Bereiche mit größerem innerem Durchmesser bilden und die Bereiche mit größerem innerem Durchmesser sich während des Schritts des Aufweitens der Bereiche mit reduziertem Durchmesser nicht aufweiten; und wobei der Aufweitschritt ausgeführt wird durch Verwendung eines Aufweitwerkzeugs (36), das einen größeren Durchmesser als der innere Durchmesser der dickeren Wandbereiche und einen kleineren Durchmesser als der innere

Durchmesser der dünneren Wandbereiche hat, um die dickeren Wandbereiche des hohlen Rohrs (13) in mechanischen Festsitzeingriff mit den Nockenelementen (10) aufzuweiten, indem das Aufweitwerkzeug (36) in das hohle Rohr (13) eingeführt wird.

Revendications

1. Procédé de fabrication d'un tube d'arbre à came comportant les étapes consistant à prévoir un tube creux (13), prévoir un mandrin rétractable s'étendant axialement (50), le mandrin rétractable (50) ayant une première partie (54) et une deuxième partie (52) adjacente à la première partie (54), le diamètre de la première partie (54) étant plus grand que le diamètre de la deuxième partie (52), la deuxième partie (52) étant une extrémité du mandrin rétractable (50), insérer le mandrin rétractable (50) dans le tube creux (13), positionner le mandrin rétractable (50) de sorte que la première partie (54) du mandrin rétractable (50) est positionnée sous une première section (18) du tube creux (13) ; prévoir un outil de forgeage (60) et réduire mécaniquement la première section (18) du tube creux (13) en poussant le tube creux (13) à travers l'outil de forgeage (60), le mandrin rétractable (50) étant également déplacé afin de maintenir la première partie (54) du mandrin rétractable (50) positionnée sous la section du tube creux (13) qui est réduite, rétracter le mandrin rétractable (50) afin de positionner la deuxième partie (52) du mandrin rétractable (50) sous une deuxième section (16) du tube creux (13), réduire mécaniquement la deuxième section (16) du tube creux (13), répéter les étapes de positionnement du mandrin rétractable (50) de sorte que la première partie (54) du mandrin rétractable (50) est positionnée sous une autre première section (18) du tube creux (13), réduire mécaniquement la première section (18) du tube creux (13) en poussant le tube creux (13) à travers l'outil de forgeage (60), le mandrin rétractable (50) étant également déplacé afin de maintenir la première partie (54) du mandrin rétractable (50) positionnée sous la section du tube creux qui est réduite, rétracter le mandrin rétractable (50) afin de positionner la deuxième partie (52) du mandrin rétractable (50) sous une autre deuxième section (16) du tube creux (13), réduire mécaniquement la deuxième section (16) du tube creux (13) en poussant le tube creux (13) à travers l'outil de forgeage (60), formant ainsi plusieurs premières sections (18) et deuxièmes sections (16), le diamètre interne d'une première section étant plus grand que le diamètre interne d'une deuxième section, lesdites premières et deuxièmes sections définissant des zones de paroi plus mince et des zones de paroi plus épaisse respectivement, prévoir plusieurs éléments de came (10), chaque élément de came (10) comprenant une ouverture axiale, insérer le tube creux (13) dans les éléments de came (10), chaque élément de came (10) étant positionné autour d'une zone de diamètre interne réduit, et dilater les zones de diamètre interne réduit du tube creux (13) en engagement d'interférence mécanique avec les éléments de came (10) ; les sections du tube creux (13) adjacentes aux zones de diamètre interne réduit définissant des zones de diamètre interne plus grand et les zones de diamètre interne plus grand ne se dilatant pas pendant l'étape de dilatation des zones de diamètre réduit ; et ladite étape de dilatation est réalisée en utilisant un outil de dilatation (36) ayant un diamètre plus grand que le diamètre interne des zones de paroi plus épaisse et plus faible que le diamètre interne des zones de paroi plus mince afin de dilater les zones de paroi plus épaisse du tube creux (13) en engagement d'interférence mécanique avec les éléments de came (10) en insérant l'outil de dilatation (36) dans le tube creux (13).

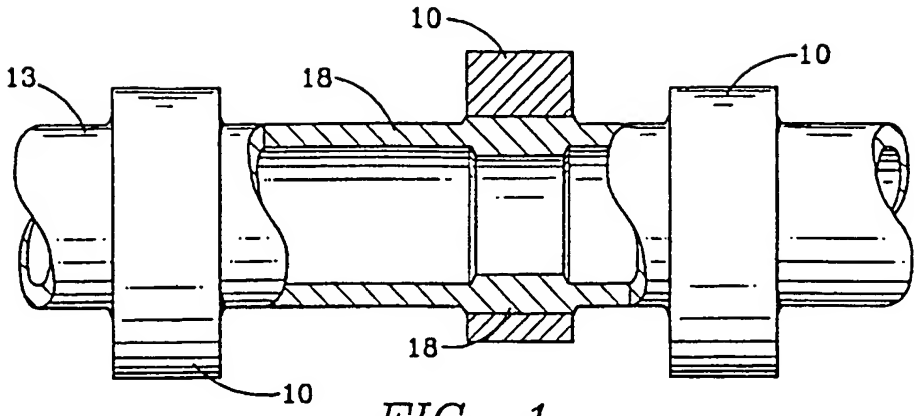

FIG. 1

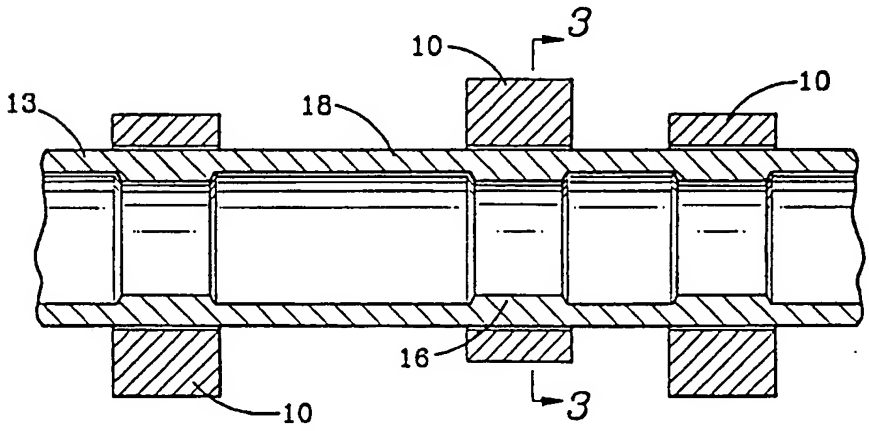

FIG. 2

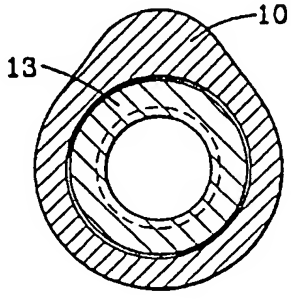

FIG. 3

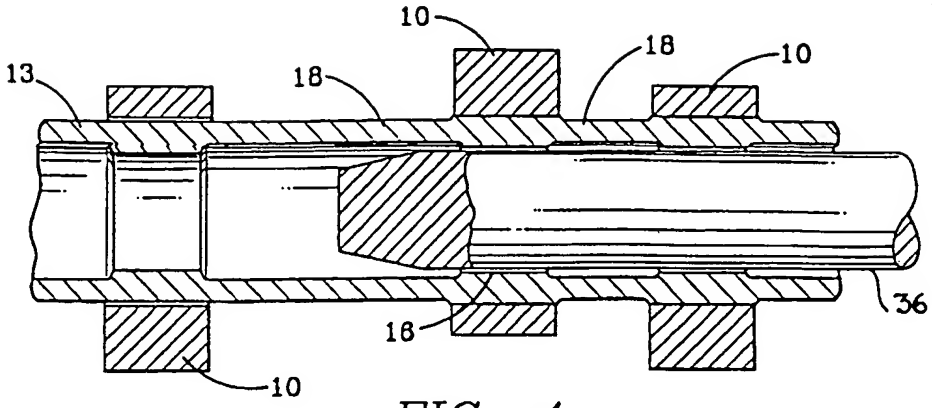

FIG. 4

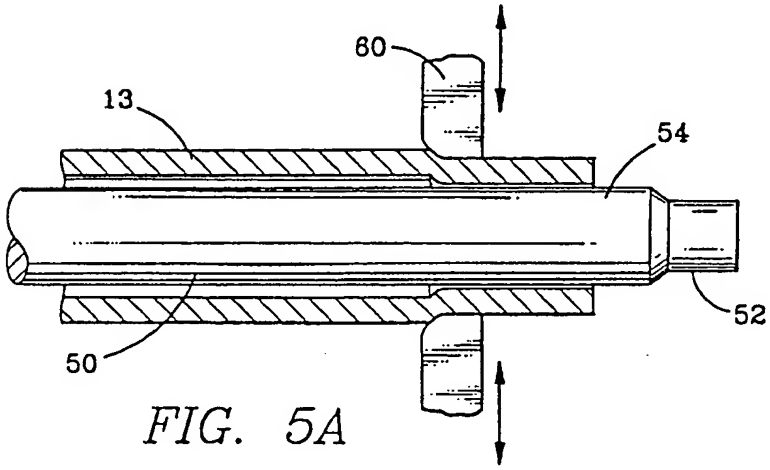

FIG. 5A

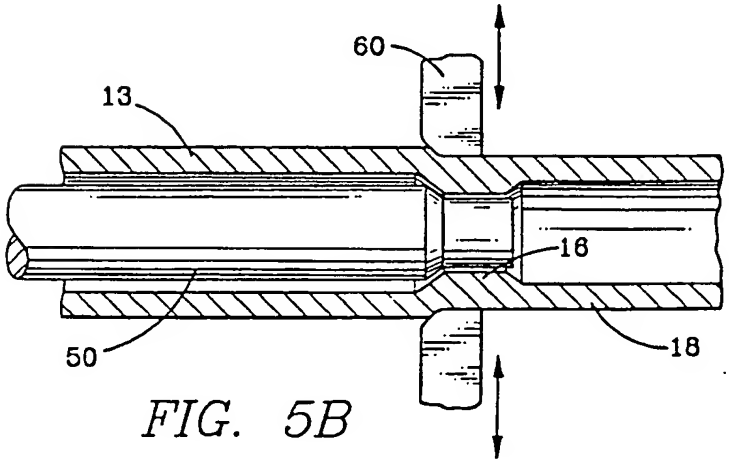

FIG. 5B

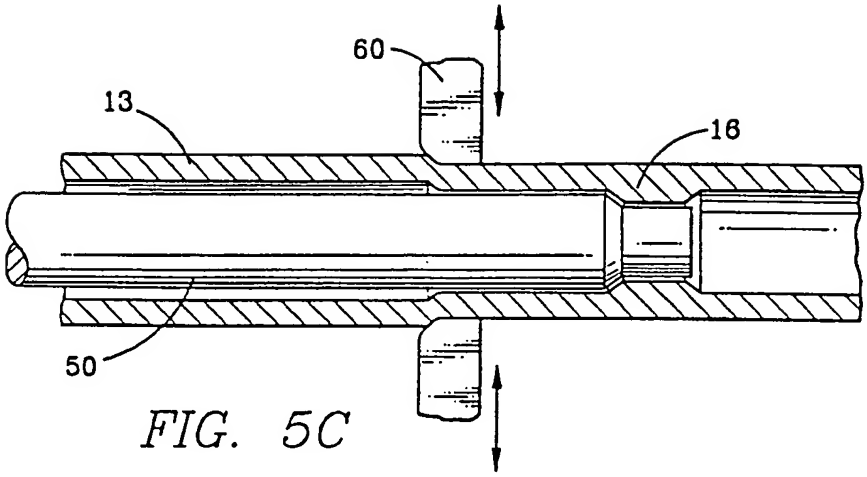

FIG. 5C

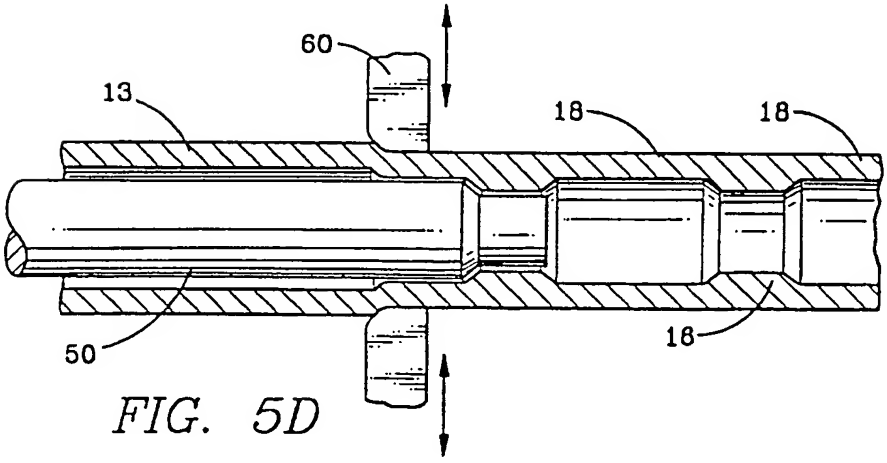

FIG. 5D